LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA26 | Washwood Heath to Curzon Street

Water resources assessment (WR-002-026)

Water resources

November 2013

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Appendix WR-002-026

Environmental topic:	Water resources and flood risk assessment	WR
Appendix name:	Water resources assessment	002
Community forum area:	Washwood Heath to Curzon Street	026

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise three parts. The first of these is a route-wide appendix (Appendix WR-001-000).

1.1.2 Several specific appendices for each community forum area (CFA) are also provided. For the Washwood Heath to Curzon Street area (CFA26), these are:

- Volume 5: Appendix WR-002-026 Water Resources Assessment report
- Volume 5: Appendix WR-003-026 Flood Risk Assessment
- Volume 5: Appendix WR-004-019 Hydraulic modelling report for the River Tame;
- Volume 5: Appendix WR-004-020 Groundwater modelling report for the Bromford tunnel portals; and
- Volume 5: Appendix WR-004-021 River modelling of the River Rea technical report.

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5: Water resources map book.

1.2 Study area

1.2.1 The Washwood Heath to Curzon Street area covers a section of Proposed Scheme 5.7km long. The area is urban in character, and lies within the built up area of Birmingham. The River Rea flows eastwards through the study area, and flows into the River Tame within the Washwood Heath area. The Grand Union and Digbeth Branch Canals intersect the area.

1.2.2 The key transport infrastructure in the area relates to a major corridor from the city centre out to the east (following the river valleys) with the Birmingham and Derby line, running broadly west (from Birmingham New Street Station) to east and also the A47 Heartlands Parkway. The Grand Union Canal and the Digbeth Branch Canal also use this corridor. Consequently there are a number of locally important public highway crossing points of the corridor (starting from the east): A4040 Bromford Lane, Aston Church Road, B4114 High Street (Saltley Viaduct), Duddeston Mill Road, and A4540 Lawley Middleway

1.2.3 The spatial scope of the assessment has been based upon the identification of surface water and groundwater features within 1km of the centreline of the route, except where there is clearly no hydraulic connectivity and in urban areas where the extent was 500m, as outside these distances it is unlikely that direct impacts upon water environment will be attributable to the Proposed Scheme. Where works extend more than 200m from the centreline of the route, for example at stations and depots, professional judgement has been used in selecting the appropriate limit to the extension in spatial scope required. As this is an urban area, a spatial scope of 500m for surface waters was used. All groundwater bodies within the centreline of 1km of the Proposed Scheme have been considered. For the purposes of this assessment this spatial scope is defined as the study area.

1.2.4 The main environmental features of relevance to water resources and flood risk include:

- the Main Rivers Rea and Tame and their associated floodplains, and Washwood Heath Brook;
- the Grand Union and Digbeth Branch Canals;
- the Bromsgrove Sandstone Principal aquifer;
- the Permeable Superficial and Arden Sandstones Secondary A aquifers;
- the Mercia Mudstone Secondary B aquifer; and
- seven licensed groundwater abstractions throughout the Washwood Heath to Curzon Street area, six of which abstract directly from the Bromsgrove Sandstones and one from the Mercia Mudstones.

1.2.5 Key environmental aspects in this area relating to water resources and flood risk include the:

- permanent reduction in natural light levels to the Digbeth Branch and Grand Union Canals;
- permanent improvement to the Washwood Heath Brook;
- permanent diversion of Washwood Heath Brook;
- permanent diversion of the River Rea Overflow Channel;
- temporary diversion of the River Tame to the east of Washwood Heath;
- temporary dewatering for Bromford tunnel west portal construction;
- potential lowering of groundwater levels and mobilisation of existing poor quality groundwater by temporary dewatering during construction, and by permanent groundwater control during operation;
- potential obstruction to groundwater flow by below ground construction and permanent structures during construction and operation;
- potential for creation or alteration of contaminant pathways during construction and operation on groundwater quality throughout the area, particularly around the industrial areas of Washwood Heath and Saltley; and
- potential impact on flood risk caused by construction works within the floodplains.

2 Stakeholder engagement

2.1.1 Consultation and discussion with the following stakeholders has been undertaken to inform the water resources assessment.

- the Environment Agency with regard to the proposed diversion of the River Tame and River Rea, river modelling and flood risk;
- the Birmingham City Council (BCC) as Lead Local Flood Authority (LLFA) and Severn Trent Water Ltd with regard to surface water drainage and flood risk in the study area and to identify any private groundwater abstractions; and
- the Canal and River Trust (formerly British Waterways) with regard to the Digbeth Branch and Grand Union Canals.

3 Baseline data

3.1 General

3.1.1 The following section provides a current description of water resources including surface water and groundwater.

3.2 Surface water features

3.2.1 All surface water features within 500m of the route are presented in Table 1.

3.2.2 The current surface water baseline is shown on Maps WR-01-042 and WR-01-043 (Volume 5: Water Resources and Flood Risk Map Book). All surface water features are based on the Environment Agency's digital river network.

3.2.3 Water bodies in this area fall within the Tame, Anker and Mease sub-catchment of the Humber River Basin District (RBD) and associated River Basin Management Plan (RBMP).

3.2.4 Topographically, the area has its high point at the western end on the ridge, where the city centre is, at approximately 110m above ordnance datum (AOD) and then falls away east along the valleys of the River Rea and then the River Tame to approximately 85m AOD at Bromford. The river valley is the dominant topographic feature that defines the land use and views in this area. It is also the basis of the local floodplain and locally important wildlife corridors.

3.2.5 The descriptive values ascribed to surface water receptors in Table 1 below have been derived in accordance with the Scope and Methodology Report (SMR) and its addendum, Volume 5 Appendix CT-001-000/1 and Volume 5 Appendix CT-001-000/2.

3.2.6 Water Framework Directive (WFD) classification data and baseline data has been made available by the Environment Agency. For water bodies that do not have a WFD status class shown in the relevant RBMP, the status class for those watercourses has been taken as the status class for the first downstream water body for which a status class is reported.

3.2.7 The route of the Proposed Scheme will cross the River Tame east of the Washwood Heath depot, the River Rea and Grand Union Canal approximately 80m east of the existing B4114 Saltley Viaduct, the River Rea approximately 350m south of Duddeston Mill Road, and the Digbeth Branch Canal approximately 180m west of A4540 Lawley Middleway. There are also several other minor watercourses, drains, overflow channels and ponds within the study area (refer to Volume 2, Section 13, CFA26 report).

Table 1: Surface water features within 500m of the route in CFA26

Water feature	**Location description**	**Classification[1]**	**Water Framework Directive[2] (WFD) water body and current overall status**	**WFD status objective (by 2027[3] as per Humber river basin management plan (RBMP)**	**Receptor value[4]**	**Q95 (m3/s)**	**Catchment/s**	**Size (km²)**	**Notes**
River Tame: from the confluence of two arms to River Blythe	Located approximately 170m north of the route then flows underneath the A47 Heartlands Parkway and the Birmingham and Derby line.	Main river	GB104028046840 Moderate Heavily modified	Good potential	High	2.05	Tame Anker and Mease	350	The River Tame flows along the north-eastern boundary of the Star City commercial development, it is then joined by the River Rea and flows eastwards through more industrial and commercial areas.

[1] Environment Agency water-feature classification: The Land Drainage Act 1991 defines an ordinary watercourse as 'A watercourse that is not part of a main river, all rivers and streams, ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers) and passages through which water flows'. 'Main Rivers' are larger rivers and streams designated by DEFRA, main rivers are regulated by the Environment Agency.

[2] The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003. London, Her Majesty's Stationery Office.

[3] Year may vary in different River Basin Management Plans.

[4] For examples of receptor values see Table 43 in the Scope and Methodology Report (SMR) Addendum, Volume 5 Appendix CT-001-000/2.

Water feature	**Location description**	**Classification[1]**	**Water Framework Directive[2] (WFD) water body and current overall status**	**WFD status objective (by 2027[3] as per Humber river basin management plan (RBMP)**	**Receptor value[4]**	**Q95 (m3/s)**	**Catchment/s**	**Size (km²)**	**Notes**
River Rea: Bourn Brook to River Tame	Located approximately 35m south of the route at the Freightliner Terminal Depot and continues west of the route where it joins with the River Tame at Washwood Heath Sidings.	Main river	GB104028042550 Bad Heavily modified	Good potential	High	Not applicable (N/A)	Tame Anker and Mease	N/A	The River Rea rises in the south-west area of Birmingham in the Lickey Hills area, approximately 17km upstream of the Proposed Scheme crossing.
Washwood Heath Brook	Located approximately 120m south of the route near the proposed Washwood Heath depot.	Ordinary watercourse	No status shown in RBMP -assumed status Moderate	No status shown in RBMP -assumed status Good potential	Moderate	N/A	Tame Anker and Mease	N/A	Mainly culverted in the lower reaches for approximately 400m prior to its confluence with the River Tame, and culverted for 500m as it passes under the main Washwood Heath industrial area.
Digbeth Branch Canal (Birmingham and Fazeley Canal Upper Section)	Canal will pass under the route south of Curzon Street.	Artificial	GB70410204 Moderate	Good potential	High	N/A	Tame Anker and Mease	N/A	-

Water feature	Location description	Classification[1]	Water Framework Directive[2] (WFD) water body and current overall status	WFD status objective (by 2027[3] as per Humber river basin management plan (RBMP)	Receptor value[4]	Q95 (m3/s)	Catchment/s	Size (km^2)	Notes
Grand Union Canal (Birmingham and Fazeley Canal Upper Section)	Located south of the existing B4114 Saltley Viaduct.	Artificial	GB70410204 Moderate	Good potential	High	N/A	Tame Anker and Mease	N/A	The route will cross the canal south of the existing B4114 Saltley Viaduct.
Pond	Located approximately 380m north of the route near University of Aston.	Not applicable	Not applicable	Not applicable	Low	N/A	Tame Anker and Mease	N/A	Isolated pond.
Pond	Located approximately 55m north of the route near the Rail Traffic Control Centre, Duddeston Mill Road.	Not applicable	Not applicable	Not applicable	Low	N/A	Tame Anker and Mease	N/A	Isolated pond.

3.2.8 There are no licensed surface water abstractions within 500m of the route.

3.2.9 Table 2 summarises surface water discharge consents within 500m of the route.

Table 2: Surface water discharge consents

Licence identifier	Distance from route (m)	Discharge type	Receiving water body
T/09/01214/T/1	Approximately 30m north of the route and south-west of Curzon Circle.	Trade discharge - process water	River Rea Overflow Channel
Tsc54	Approximately 210m west of the route.	Public sewage: storm sewage overflow	Grand Union Canal
T/09/03558/O/3	Approximately 10m east of the route near Unit 5B at Saltley Business Park, outlet 3.	Sewerage and other matter discharge - sewerage and surface water	River Rea
T/09/03558/O/2	Approximately 5m north-west of route at Unit 5B of Saltley Business Park, outlet 2.	Sewerage and other matter discharge - sewerage and surface water	River Rea
T/09/03558/O/1	Approximately 80m west of the route near to bakery on Mainstream Way, outlet 1.	Sewerage and other matter discharge - sewerage and surface water	River Rea
Tsc2013	Approximately 80m west of the route near to bakery on Mainstream Way.	Public sewage: storm sewage overflow	River Rea
Tsc1445	Approximately 310m south of the route near to Washwood Heath Depot.	Public sewage: storm sewage overflow	River Rea
CT/10/09369/O|1	Approximately 220m south of the route at Bromford Bridge. Three outlets.	Sewage effluent discharge - storm effluent	River Tame
CT/10/09369/O|3	Approximately 220m south of the route at Bromford Bridge. Three outlets.	Sewage effluent discharge-storm effluent	River Tame

Licence identifier	Distance from route (m)	Discharge type	Receiving water body
T/10/09369/O	Approximately 220m south of the route at Bromford Bridge. Three outlets.	Public sewage: storm sewage overflow	River Tame
T/10/21714/O	Located approximately 45m north of the route; on the River Tame and 45m south of the M6.	Sewage discharges - pumping station - water company	River Tame
CT/08/35090/T|2	Approximately 350m north of the route at Jarvis Way west of Gravelly Industrial Park.	Trade discharge - process water	River Tame
CT/09/35021/O|1	Approximately 275m north-west of the route at River Rea and 80m west of the A47 Heartlands Parkway.	Storm sewage overflow discharge	River Rea
T/09/21262/O	Approximately 100m west of the route close to B4114 Saltley Viaduct.	Public sewage: storm sewage overflow	River Rea
T/09/08852/O	Approximately 150m south of the route at Freightliner Terminal Depot.	Public sewage: storm sewage overflow	River Rea
T/08/11034/T/1	Approximately 350m north of the route at Jarvis Way, west of Gravelly Industrial Park.	Trade discharge - process water	River Tame
T2072/1	Approximately 602m south of the route at 15 to 17 New Bartholomew Street.	Trade discharge - process water	Digbeth Branch Canal
T2072/2	Approximately 65m south of the route 15 to 17 New Bartholomew Street.	Trade discharge - process water	Digbeth Branch Canal
T/09/07288/T/1	Approximately 140m east of the route on Towing Path at Network Park industrial estate.	Cooling water	Grand Union Canal

Licence identifier	Distance from route (m)	Discharge type	Receiving water body
Tsc1078	Approximately 240m south-east of the route 55m west of Montague Street.	Public sewage: storm sewage overflow	River Rea
T/09/21544/O	Approximately 240m south of the route and 609m west of Montague Street.	Public sewage: storm sewage overflow	River Rea
T/09/36271/O	Approximately 450m south of the route at factory west of River Street.	Public sewage: storm sewage overflow	River Rea
CT/10/35023/O|1	Approximately 280m north of the route at River Rea and 90m south east of Watson Road.	Sewage effluent discharge-storm effluent	River Rea
Tsc1312	Approximately 230m south of the route; 55m west of Montague Street.	Public sewage: storm sewage overflow	River Rea
T/09/21164/O	Approximately 235m south of the route; 55m west of Montague Street.	Public sewage: storm sewage overflow	River Rea
Tsc1311	Approximately 200m south of the route and 10m west of Montague Street.	Public sewage: storm sewage overflow	River Rea
Tsc576	Approximately 235m south of the route and 55m west of Montague Street.	Public sewage: storm sewage overflow	River Rea
T/09/36424/O	Approximately 255m south on Bordesley Street near Ladbroke House.	Public sewage: storm sewage overflow	Digbeth Branch Canal
Tsc124	Approximately 10m south-east of the route on Aston Church Road.	Public sewage: storm sewage overflow	River Rea

Licence identifier	Distance from route (m)	Discharge type	Receiving water body
Tsc257	Approximately 15m north-west of the route and 70m south of A47 Heartlands Parkway.	Public sewage: storm sewage overflow	River Rea
T/09/36399/O	Approximately 5m south-east of the route on River Rea.	Public sewage: storm sewage overflow	River Rea
T/09/21545/O	Approximately 240m south of the route and 60m west of Montague Street.	Public sewage: storm sewage overflow	River Rea
Tsc2012	Approximately 340m south-east of the route and 25m west of Aston Church Road.	Public sewage: storm sewage overflow	N/A
T/09/36114/O	Approximately 15m west of the route and 70m east of A47 Heartlands Parkway.	Public sewage: storm sewage overflow	River Rea
Tsc1716	Approximately 450m south-east of the route and 80m west of 264 Church House in Washwood Heath.	Public sewage: storm sewage overflow	N/A
T/09/07539/T/2	Approximately 130m south of the route at Freightliner Terminal Depot.	Site drainage	River Rea
Tsc1719	Approximately 15m west of the route and 70m west of Unit 5B on Cumbria Way.	Public sewage: storm sewage overflow	River Rea
T/10/00845/T/1	Approximately 170m south of the route and 50m north of Bromford Bridge.	Trade discharge - process water	River Tame
Tsc2055	Approximately 455m south of the route and 35m west of 264 Church House in Washwood Heath.	Public sewage: storm sewage overflow	N/A

Licence identifier	Distance from route (m)	Discharge type	Receiving water body
Tsc1127	Approximately 370m south of the route at Works on Fazeley Street.	Public sewage: storm sewage overflow	River Rea
Dt/9825	Approximately 425m south of the route at Upper Mill Lane.	Public sewage: storm sewage overflow	N/A

3.3 Groundwater

3.3.1 Baseline information is shown on Volume 5: Map WR-02-026.

3.3.2 The underlying solid geology comprises the Mercia Mudstone Group as far west as the Birmingham Fault, which lies between Penn Street and Cardigan Street. Mercia Mudstone typically comprises a weak red brown silty mudstone with minor amounts of carbonate and gypsum when unweathered. The Arden Sandstone Formation occurs within the Mercia Mudstone as a thin discontinuous horizon of siltstone and sandstone, although this is much higher in the sequence, to the east of Birmingham.

3.3.3 The Bromsgrove Sandstone Formation, which is part of the Sherwood Sandstone Group, is present to the west of the Birmingham Fault across the remainder of the study area. During previous investigations in the vicinity[5], groundwater was monitored at depths of 2m-5.5m below ground level within the glaciofluvial deposits and weathered Bromsgrove Sandstones near Curzon Street[6].

3.3.4 Superficial glacial deposits form a discontinuous layer across the upper parts of the River Rea valley and River Tame valley sides. In particular, glacial deposits are present across the area east of Aston Church Road and continue beneath this section of the Proposed Scheme as far as the proposed Curzon Street station. A notable feature is a buried glacial channel up to 30m deep and infilled with glacial deposits at Aston Church Road and Network Park industrial estate. The route of the Proposed Scheme will follow the valley bottom of the River Tame and River Rea, an area that is underlain by widespread deposits of alluvium and river terrace deposits.

[5] Arup (2009, *Birmingham City University City Centre Campus Phase 2 Interpretive Ground Investigation*, 207688.

[6] Arup (2012), *High Speed Two Ltd, West Midlands Metropolitan Area, Contract 224, Geotechnical Desk Study Report*, C224-ARP-GT-REP-040000001, P01.0.

3.3.5 There are known areas of made ground identified within the study area which are associated with land raising, as part of general development and highway and railway infrastructure earthworks. Areas of particular note include the Birmingham and Derby line, the former Alstom site, the former Leyland DAF Vans (LDV) site, Mount Street Business Centre, Mainstream Industrial Park and Network Park industrial estate.

3.3.6 Made ground is consistently present from the start of the study area, approximately 500m east of Bromford Lane, to approximately 250m east of Aston Church Road, between Saltley Business Park and Freightliner Terminal Depot, and from Curzon Circle to the western extent of the study area at Park Street.

3.3.7 In addition, intermittent made ground is also present between approximately 130m east of Aston Church Road and around 10m east of High Street (existing B4114 Saltley Viaduct), and between the A4540 Lawley Middleway and approximately 350m east of the A4540 Lawley Middleway.

3.3.8 There are three geological units that are aquifers within the study area: the Bromsgrove Sandstone, the glaciofluvial deposits and the Mercia Mudstone and Arden Sandstone. The Bromsgrove Sandstone is a Principal aquifer. The river terrace deposits and alluvium are a Secondary A aquifer. The Mercia Mudstone is a Secondary B aquifer and where the Arden Sandstone is present within the Mercia Mudstone this is classed as a Secondary A aquifer.

3.3.9 There are three groundwater source protection zones located within the study area. These are associated with the abstractions at The Grand Hotel, the Burlington Hotel and a third unlicensed source at Aston Manor. The source protection zones are 560m, 570m and 780m from the centreline of the route, respectively.

3.3.10 Table 3 summarises licensed groundwater abstractions within 1km of the route (see Volume 5: Map WR-02-026). There are no groundwater discharge consents within 1km of the route.

Table 3: Licensed groundwater abstractions

Licence ID (map reference no and Environment Agency reference)	**Distance from route (m)**	**Abstraction horizon**	**Max annual abstraction quantity (m^3/year)**	**Max daily abstraction quantity (m3/d)**	**Number of boreholes**
03/28/10/0033 Meggitt Aerospace Limited – Fort Dunlop	Approximately 580m north-west	Bromsgrove Sandstones	Unknown	Unknown	Unknown
03/28/10/0036 LDV Group Limited - land at Washwood Heath	Approximately 450m north-west-west	Bromsgrove Sandstones	Unknown	Unknown	2
03/28/09/0099 Smurfit Kappa UK Limited – St Clement Street	Approximately 320m south-west-west	Bromsgrove Sandstones	Unknown	Unknown	2
03/28/09/0050 The Grand Hotel	Approximately 680m	Bromsgrove Sandstones	Unknown	Unknown	2
03/28/09/0051 The Burlington Hotel	Approximately 620m	Bromsgrove Sandstones	Unknown	Unknown	2
03/28/09/0113 Aggregate Industries Limited – Bordesley Green Road	Approximately 810m	Mercia Mudstones	Unknown	Unknown	Unknown
MD/028/0009/005 Azko Noble Limited	Approximately 940m	Bromsgrove Sandstones	Unknown	Unknown	2

3.4 Groundwater/surface water interaction

3.4.1 Table 4 summarises groundwater/surface water interactions within 1km of the route.

Table 4 : Groundwater/surface water interaction

Location description	Distance from route	Formation	Elevation (mAOD)	Comments
River Rea	0m (crosses route)	Permeable superficial deposits	99	Site specific information on dependence is not available. Assumed connection though permeable superficial deposits[7]. Further pre-construction assessment required.
River Tame	0m (crosses route)	Permeable superficial deposits	To the west: 83 to 88	Site specific information on dependence is not available. Assumed connection though permeable superficial deposits. Further pre-construction assessment required.

[7] Knipe, C.V., Lloyd, J.W., Lerner, D.N. and Greswell, R. (1993), Rising Groundwater levels in Birmingham and the engineering implications, CIRIA Special Publication

3.5 Water dependent habitats

3.5.1 There are no water dependent habitats within 1km of the route.

4 Site specific assessments

4.1 Surface water

4.1.1 Table 5 summarises the potential impacts and effects to surface water. This only includes features which could potentially be impacted by the Proposed Scheme. Features such as isolated ponds and drains which will lie outside the land required for the Proposed Scheme, are not included. However, details of the features are provided in Table 5. Where the ecology of water features is impacted these are assessed and presented within the ecology assessment (see Volume 2, Section 7, CFA 26).

Table 5: Summary of potential impacts to surface water

Surface water feature / receptor	Value of water feature	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Mitigation measures included in design	Magnitude of remaining impact and significance of effect	Further mitigation	Residual effect	Duration of effect
River Tame, River Rea, Grand Union Canal, and Digbeth Branch Canals	High	Rail and associated infrastructure	Potential impact on water quality from sediments, fuel/oils chemicals, concrete and flow of run-off from construction areas, specifically in relation to areas close to watercourse crossings.	Minor adverse Moderate (significant)	Application of measures identified in the draft CoCP Section 16 regarding control of site drainage from earthworks and construction sites, and procedures to follow BS6031[8] code of practice for earthworks. Together with other measures outlined in section 16 of the draft CoCP.	Negligible impact (neutral effect not significant)	None required	Neutral	Construction (temporary)

[8] BS6031: 2009, Code of Practice for Earthworks

Surface water feature / receptor	Value of water feature	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Mitigation measures included in design	Magnitude of remaining impact and significance of effect	Further mitigation	Residual effect	Duration of effect
River Tame	High	Bromford bored tunnel - including bed protection in the River Tame, and temporary coffer dam diversions for bed protection construction.	Potential impacts on water quality from runoff of water containing sediments, oil, fuel, concrete wash water from construction areas. Re-suspension of sediments from coffer dams and temporary works.	Minor adverse Moderate (significant)	Application of measures identified in the draft CoCP Section 16 will require the contractors to undertake risk assessments associated with excavation works and dewatering impacts on surface water, groundwater and abstractions. This would identify site-specific mitigation measures to be used during the construction period.	Negligible impact (neutral effect not significant)	None required	Neutral	Construction (temporary)
River Tame	High	Tunnel portal, retaining wall and cutting.	Potential impact on water quality from runoff of water containing sediments, oil, fuel, concrete wash water from construction areas. Cutting construction will require dewatering, with potential disposal of dewatered fluid into the Tame.	Minor adverse Moderate (significant)	Application of measures identified in the draft CoCP including control of site drainage from earthworks and construction sites, and procedures following BS6031 code of practice for earthworks (see draft CoCP Section 16) together with other measures outlined in section 16 of the draft CoCP.	Negligible impact (neutral effect not significant)	None required	Neutral	Construction (temporary)

Surface water feature / receptor	Value of water feature	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Mitigation measures included in design	Magnitude of remaining impact and significance of effect	Further mitigation	Residual effect	Duration of effect
All watercourses	High	Bridge Structures - not over watercourses	Potential impacts on water quality through surface water drainage from runoff of water containing sediments, oil, fuel, concrete wash water from construction areas.	Negligible Neutral (not significant)	N/A	Negligible impact (neutral effect not significant)	None required	Neutral	Construction (temporary)
River Rea	High	River Rea diversion	Potential impact on water quality from runoff of water containing sediments, oil, fuel, concrete wash water from construction areas.	Minor adverse Moderate (significant)	Application of measures identified in the draft CoCP including control of site drainage from earthworks and construction sites, and procedures following BS6031 Code of practice for earthworks (see draft CoCP Section 16) Together with other measures outlined in section 16 of the draft CoCP.	Negligible impact (neutral effect not significant)	None required	Neutral	Construction (temporary)

Surface water feature / receptor	**Value of water feature**	**Design element**	**Discussion of potential impact to water receptor**	**Magnitude of potential impact and effect**	**Mitigation measures included in design**	**Magnitude of remaining impact and significance of effect**	**Further mitigation**	**Residual effect**	**Duration of effect**
Grand Union and Digbeth Branch Canals	High	Canal overbridges near the B4114 Saltley viaduct and the Curzon Street No.3 viaduct.	Potential impact on water quality from runoff of water containing sediments, oil, fuel, concrete wash water from construction areas.	Minor adverse Moderate (significant)	Application of measures identified in the draft CoCP including control of site drainage from earthworks and construction sites, and procedures following BS6031 Code of practice for earthworks (see draft CoCP Section 16) Together with other measures outlined in section 16 of the draft CoCP	Negligible impact (neutral effect not significant)	None required	Neutral	Construction (temporary)

Surface water feature / receptor	Value of water feature	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Mitigation measures included in design	Magnitude of remaining impact and significance of effect	Further mitigation	Residual effect	Duration of effect
Washwood Heath Brook and River Tame	Moderate	Re-profiling of site and construction of Washwood Heath depot.	Potential impacts on water quality from runoff of water containing sediments, oil, fuel, concrete wash water from construction areas. Potential for exposing ground materials which may contain contaminants.	Minor adverse Moderate (significant)	Application of measures contained in the draft CoCP Section 16 includes provision of a suitable construction site drainage system including cut-off ditches or drains and sustainable drainage systems, or equivalent, with suitably sized treatment facilities such as settlement or balancing ponds ; "appropriate measures such as the use of bunds of non-erodable material or silt or sediment fences adjacent to watercourses"; and "the good working practices detailed in the Environment Agency's Pollution Prevention Guidelines will be adopted", Temporary construction methods and CIRIA publications (including C532[9], C648[10] and C649[11]).	Negligible impact (neutral effect not significant)	None required	Neutral	Construction (temporary)

[9] Construction Industry Research and Information Association (CIRIA) C532 (2001), Control of water pollution at construction sites, CIRIA.

Surface water feature / receptor	Value of water feature	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Mitigation measures included in design	Magnitude of remaining impact and significance of effect	Further mitigation	Residual effect	Duration of effect
Washwood Heath Brook	Moderate	Diversion of Washwood Heath Brook	Potential impacts on water quality from runoff of water containing sediments, oil, fuel, concrete wash water from construction areas.	Minor adverse Moderate (significant)	Application of measures identified in the draft CoCP section 16 regarding control of site drainage from earthworks and construction sites, and procedures to follow BS6031 Code of Practice for Earthworks. Together with other measures outlined in section 16 of the draft CoCP.	Negligible impact (neutral effect not significant)	None required	Neutral	Construction (temporary)
River Rea	High	Construction of proposed Curzon Street station and Curzon Street No. 3 viaduct	Potential impact on water quality from runoff of water containing sediments, oil, fuel, concrete wash water from construction areas.	Minor adverse Moderate (significant)	Application of measures identified in the draft CoCP Section 16 regarding control of site drainage from earthworks and construction sites, and procedures to follow BS6031 Code of Practice for Earthworks. Together with other measures outlined in section 16 of the draft CoCP.	Negligible impact (neutral effect not significant)	None required	Neutral	Construction (temporary)

[10] CIRIA C648 (2006); *Control of water pollution from linear construction projects*; CIRIA.

[11] CIRIA C649 (2006); *Control of water pollution from linear construction projects: Site Guide*; CIRIA.

Surface water feature / receptor	Value of water feature	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Mitigation measures included in design	Magnitude of remaining impact and significance of effect	Further mitigation	Residual effect	Duration of effect
Grand Union and Digbeth Brach Canals	High	Viaducts crossing over the canal	Reduction in natural light level to canal inhibiting the growth of oxygenating plants and affecting dissolved oxygen balance.	Minor adverse Moderate (significant)	The height of the crossings will partially offset these effects.	Minor adverse Moderate (significant)	None possible	Significant	Permanent
Washwood Heath Brook	Moderate	River diversion and de-culverting	Improved dissolved oxygen balance from the in-line cascade feature and increased natural light levels.	Moderate beneficial Moderate (significant)	N/A	Minor beneficial Moderate (significant)	N/A	Significant	Permanent
River Tame	High	Routine drainage from track infrastructure	Potential for reduction in water quality from track drainage.	Minor adverse (significant)	Balancing ponds located adjacent to the Washwood Heath depot. These discharge to the River Tame and will improve the quality of track drainage water discharging into the River Tame.	Negligible impact (neutral effect not significant)	None required	Neutral (not significant)	Permanent

Surface water feature / receptor	Value of water feature	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Mitigation measures included in design	Magnitude of remaining impact and significance of effect	Further mitigation	Residual effect	Duration of effect
River Rea	High	Routine drainage from track infrastructure	Potential for reduction in water quality from track drainage.	Minor adverse (Significant)	Balancing ponds located adjacent to the route between the Saltley viaduct and Curzon Street No. 3 viaduct. These discharge to the River Rea and will improve the quality of track drainage water discharging into the River Rea.	Negligible impact (neutral effect not significant)	None required	Neutral (not significant)	Permanent

4.2 Groundwater

4.2.1 Table 6 summarises the potential impacts to groundwater, and groundwater/surface water interactions. Only those impacts and effects that are classed as significant are presented in the Volume 2, Section 13.4 CFA26 report.

Table 6: Summary of potential impacts to groundwater and groundwater/surface water interactions

Water feature / receptor	Value of water feature	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Mitigation measures included in design	Magnitude of remaining impact and significance	Further mitigation	Residual effect	Duration of effect
River Tame	High	Cutting for the Bromford tunnel west portal.	Temporary dewatering affecting groundwater levels and quality.	Minor adverse (significant)	The draft CoCP Section 16 includes good practice measures for waste water and groundwater management. Remove or breakthrough cut-off structures following construction, incorporate passive bypasses within the design, incorporate collars in these passive bypasses to avoid creating artificial flow paths, implement a regime of post construction monitoring of groundwater levels.	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction temporary
		All below ground construction sites and structures e.g. cuttings and foundations.	Barriers of low permeability affecting groundwater levels and quality.	Minor adverse (significant)	The draft CoCP Section 16 includes good practice measures for waste water and groundwater management.	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction temporary

River Rea	High	Cutting for the Bromford tunnel west portal.	Temporary dewatering affecting groundwater levels and quality	Negligible (not significant)	The draft CoCP Section 16 includes good practice measures for waste water and groundwater management.	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction temporary
		All below ground construction sites and structures. e.g. such as the piling associated with Grand Union Canal underbridge and Curzon Street No. 3 viaduct.	Barriers of low permeability affecting groundwater levels and quality.	Minor adverse (significant)	The draft CoCP Section 16 includes good practice measures for waste water and groundwater management.	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction temporary
Bromsgrove Sandstone	High	All below ground construction sites and structures such as the piling associated with Grand Union Canal underbridge and Curzon Street No. 3 viaduct.	Barriers of low permeability affecting groundwater levels and quality.	Minor adverse (significant)	The draft CoCP Section 16 includes good practice measures for waste water and groundwater management.	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction temporary

Permeable superficial deposits, Mercia Mudstones and Arden Sandstones	Moderate	Cutting for the Bromford tunnel west portal.	Temporary dewatering affecting groundwater levels and quality.	Minor adverse (not significant)	The draft CoCP Section 16 includes good practice measures for waste water and groundwater management.	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction temporary
		All below ground construction sites and structures for the Bromford tunnel west portal.	Barriers of low permeability affecting groundwater levels and quality.	Minor adverse (not significant)	The draft CoCP Section 16 includes good practice measures for waste water and groundwater management.	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction temporary
River Tame	High	Cutting for the Bromford tunnel west portal.	Permanent groundwater control affecting groundwater levels and quality.	Minor adverse (significant)	Remove or breakthrough cut-off structures following construction, incorporate passive bypasses within the design, incorporate collars in these passive bypasses to avoid creating artificial flow paths, implement a regime of post construction monitoring of groundwater levels.	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction permanent
		All below ground construction sites and structures for the Bromford tunnel west portal.	Barriers of low permeability affecting groundwater levels.	Minor adverse (significant)	As above	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction permanent

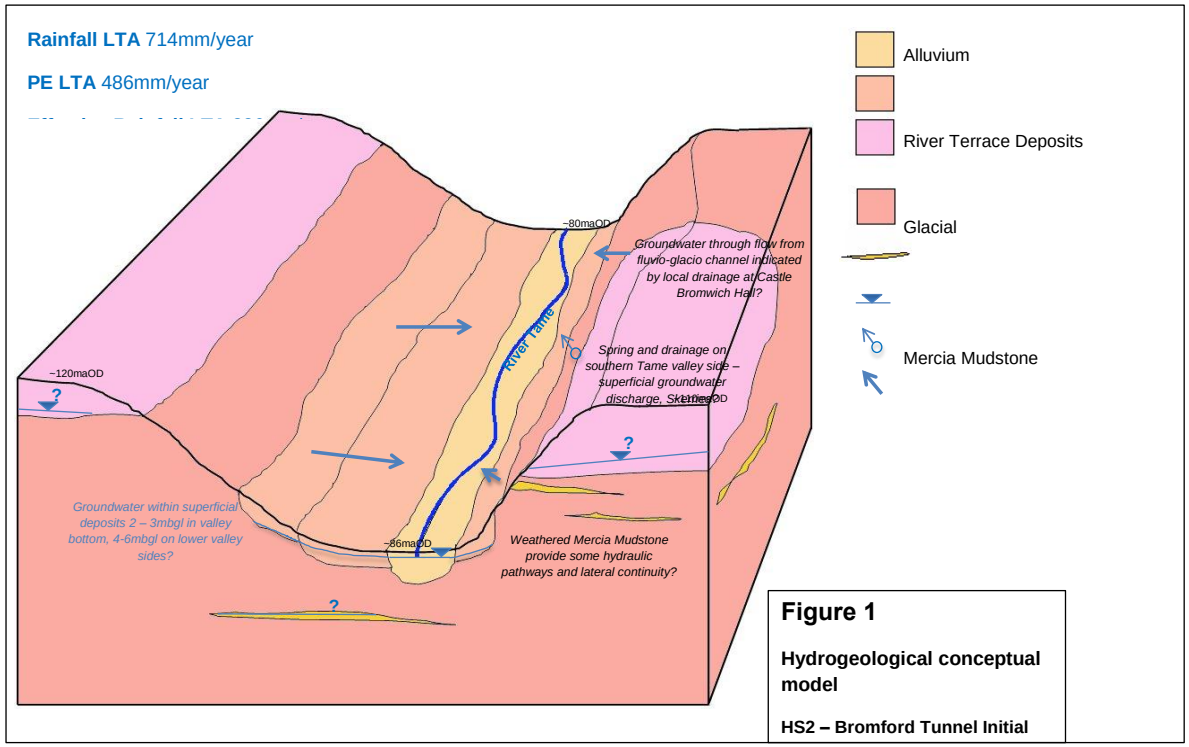
River Rea	High	Cutting for the Bromford tunnel west portal.	Permanent groundwater control affecting groundwater levels and quality.	Negligible (not significant)	As above	Negligible Neutral (not significant)	None required	Neutral	Construction permanent
		All below ground construction sites and structures such as the piling associated with Grand Union Canal underbridge and Curzon Street station and Curzon Street No 3 viaduct.	Barriers of low permeability affecting groundwater levels.	Minor adverse (significant)	As above	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction permanent

Bromsgrove Sandstone	High	All below ground construction sites and structures such as the piling associated with Grand Union Canal underbridge and Curzon Street station and Curzon Street No.3 viaduct.	Barriers of low permeability affecting groundwater levels.	Minor adverse (significant)	As above	Negligible impact Neutral effect (not significant)	None required	Neutral	Construction permanent
Permeable superficial deposits, Mercia Mudstones and Arden Sandstones	Moderate	Cutting for the Bromford tunnel west portal.	Permanent groundwater control affecting groundwater levels and quality.	Minor adverse (not significant)	As above	Negligible effect Neutral (not significant)	None required	Neutral	Construction permanent

4.3 Detailed assessment

Groundwater assessment of the Bromford tunnel west portal

Figure 1: Conceptual hydrogeological model used to investigate potential groundwater effects due to the tunnel portals



4.3.2 There is a potential impact on groundwater flow to the River Tame from the construction of the Bromford tunnel west portal, where the portal passes through the Secondary aquifer superficial deposits, potentially cutting off some groundwater flow to the River Tame.

4.3.3 A conceptual model of the local geology and likely flow pathways has been developed based on publically available geological information, mapping and the environmental baseline. This conceptual model has been used to construct a preliminary 3D numerical model using Visual MODFLOW to better understand the likely changes that may arise following the construction of the tunnel portal.

4.3.4 The conceptual model is as follows:

4.3.5 The superficial deposits have been categorised into the following strata and associated thicknesses based on BGS borehole records and 1:10,000 superficial geology map:

- first river terrace deposits, 3m thick;
- second river terrace deposits, 4m thick;
- glaciofluvial deposits, ranging between 4m to 15m thick; and
- alluvium, 6m thick.

4.3.6 All of these deposits are generally described as being free draining sands and gravels. The underlying bedrock of the Mercia Mudstone is expected to be weathered in its upper 10 to 15m, with glacial and alluvial materials deposited and infilling hollows within the bedrock. Siltstone and sandstone "skerry" bands occur in places and are thought to occur on the southern side of the Tame valley in the area of the steep "cliff".

4.3.7 In terms of hydrogeology, the glacial and fluvial superficial deposits are all considered Secondary A aquifers and generally described as sand and gravel materials which are considered permeable (permeability $1x10^{-6}$m/s).

4.3.8 The underlying Mercia Mudstone is a Secondary B aquifer with permeability of $1x10^{-9}$m/s, and generally much less permeable than the overlying superficial deposits. The Mercia Mudstone is expected to be weathered in its upper 10 to 15m and include more permeable siltstone/sandstone “skerry” bands in places which can be water bearing.

4.3.9 Groundwater within the valley bottom is expected to be shallow adjacent to the river, 1 to 3m below ground level, and at greater depth on the valley sides. Groundwater flow within the superficial deposits is expected to follow the topography. Springs and density of local drainage on the southern valley side may indicate shallow groundwater flow to the north into the Tame valley from the river terrace and glaciofluvial deposits and possibly “skerry” bands.

4.3.10 The long term average rainfall for the area is approximately 714mm/year, and the potential evaporation is approximately 486mm/year, meaning an effective rainfall of approximately 226mm/year. The largely urban catchment with areas of hard standing would mean that there will be a significant component of run-off reducing infiltration recharge.

4.3.11 The River Tame is the main drainage feature, which is embanked and a modified channel in places, but is assumed to generally be in continuity with groundwater. The Environment Agency gauging station downstream at Water Orton has a Baseflow Index (BFI) of 0.50, indicating that a significant proportion of the baseflow to the river is comprised of groundwater flow.

4.3.12 A two layer three dimensional (3D) calibrated numerical model was constructed. The model was run in transient mode for a period of one year. Preliminary calibration was undertaken by systematically altering model properties and boundary conditions to obtain a best fit between the modelled groundwater levels and observed groundwater levels, or water strikes. The calibrated model was subsequently used to predict the impact on groundwater levels by the presence of the portals.

4.3.13 The results from the modelling have identified the potential for the Bromford tunnel west portal to act as barriers to groundwater flow with localised increases in groundwater levels on the up-hydraulic gradient side of the portals, and decreases in groundwater levels on the down-hydraulic side of the portals. This would potentially result in a moderate adverse impact and a significant effect on groundwater flow to the River Tame.

4.3.14 The effect of decreasing groundwater flow to the River Tame in the areas of the Bromford tunnel west portal could be mitigated by a variety of measures such as the inclusion of a passive bypass for groundwater control. The exact form of mitigation will be determined following pre-construction investigations, including a regime of groundwater monitoring, and more detailed groundwater modelling. Following the implementation of appropriate mitigation, it is considered that this would result in no significant effect.

4.3.15 Additionally, the implementation of a regime of post-construction monitoring of groundwater would verify the success of the mitigation measures.

Groundwater assessment of the cuttings

4.3.16 Table 7 summarises the excavations and the requirement for groundwater control. Only those impacts and effects that are classed as significant are presented in the Volume 2, Section 13.4 CFA26 report.

Table 7: Summary of cuttings and requirement for groundwater control

Cutting name and depth	Geology penetrated	Groundwater elevation	Potential impact on groundwater resources	Mitigation measures	Residual significance
Bromford tunnel	Made Ground, Alluvium, Sand and Gravel over Mercia Mudstone Formation. Arden Sandstone present.	Tunnel below water table	Tunnel boring machine construction in low permeable Mercia Mudstone. No impact on groundwater resources.	Not required.	Not significant
Bromford tunnel east portal retained cutting and cut and cover (in CFA25 Castle Bromwich and Bromford)	Made Ground, Alluvium, Sand and Gravel over Mercia Mudstone Formation. Arden Sandstone present.	Cutting below water table	Interception of Alluvium, Sand and Gravel, Mercia Mudstone Formation, Arden Sandstone groundwater.	Pre-construction investigations to confirm requirement. If required, mitigation includes temporary and permanent groundwater control.	Not significant
Retained cutting near Washwood Heath rail overbridge	Made Ground, Alluvium, Sand and Gravel over Mercia Mudstone Formation. Arden Sandstone present.	Cutting above water table.	Interception of groundwater unlikely.	Pre-construction investigations to confirm requirement. If required, mitigation includes temporary and permanent groundwater control.	Not significant

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